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PATENT SPECIFICATION

440,469

Application Date: May 3, 1935. No. 13206/35.

Complete Specification Accepted: Dec. 31, 1935.

COMPLETE SPECIFICATION

Improvements in and relating to Elastic-fluid Turbine Blades

We, C. A. PARSONS & COMPANY, LIMITED, of Heaton Works, Newcastle-on-Tyne, in the County of Northumberland, a British Company, do hereby declare the nature of this invention (a communication to us from abroad by Allis-Chalmers Manufacturing Company, of Milwaukee, Wisconsin, United States of America, a corporation of Delaware, United States of America) and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates generally to the art of manufacturing steam turbine blade segments or the like and more particularly to a method of uniting nickel-chrome-steel turbine blades to form a blade segment.

Processes heretofore successfully practised in uniting steam turbine blades of copper-nickel composition or of similar material have been found to be quite inadequate when applied to the uniting of blades of stainless nickel-chrome steel, since such alloys as silver solder, which are ordinarily utilised for the purpose of uniting blades, do not adhere readily to nickel-chrome steel.

Further, it has been found that the strength of nickel-chrome steel may be seriously impaired by reason of grain growth in the steel if it is heated, during the uniting process, materially above the minimum temperature at which union with the alloy may be effected.

It is an object of the present invention to provide a method of uniting an alloy to a nickel-chrome-steel turbine blade securely and without detrimentally affecting the internal structure of the nickel-chrome-steel.

With such a main object, the present invention consists in a process of uniting a co-operating element to a nickel-chrome-steel blade, which includes the step of electroplating said blade with silver prior to the actual operation of uniting the blade and co-operating element.

Referring to the accompanying drawing:—

Figure 1 is a plan view of a blade-spacing and -angling jig utilized in manufacturing turbine-blade segments;

Figure 2 is a corresponding central vertical sectional view taken on line II—II of Figure 1;

Figure 3 is a view showing in elevation a completed blade segment;

Figure 4 is a longitudinal section of a blade segment together with a portion of a blade-segment-supporting element, and

Figure 5 is an elevation of one of the blade-spacing and angling strips with a blade positioned in one of the notches provided therein.

This invention contemplates the use of nickel-chrome stainless steel, as a material from which the blades may be made. This steel is very tough and is especially suitable for turbine-blade construction. In order, however, to produce a more effective and firmer union between the blades and the adjacent portions of the co-operating shroud, lacing wire and foundation segments than has heretofore been possible, this invention contemplates plating of the nickel-chrome blades with a suitable metal. Silver has been found to be a suitable plating metal for this purpose. Since the art of electroplating is well developed no further disclosure of this feature of the invention is necessary, as any of the well-known electroplating methods may be used in carrying out this step of this invention.

After the blades have been electroplated with silver, they are arranged and held in segmental formation in a blade-spacing and -angling jig which will later be described. A shroud segment, 16, is then attached to corresponding ends of the blades by help of silver solder which fuses at a temperature considerably below 1760° Fahrenheit, the melting point of silver.

It has been observed that when the nickel-chrome steel of which the blades are made is heated above 1700° F., grain growth may occur therein. This change of structure of the blade material greatly affects the strength of the blades, making them much weaker than before the heat treatment. To avoid this condition, the operator observes the action of the flame

used in brazing the silver solder against the blades and when the silver plating begins to vanish by fusion he is aware that the flame is of such a high temperature that the further use of the flame will result in great injury to the blades, and that he should therefore adjust the flame to a safe working temperature. This is one of the advantages of the step of silver plating the nickel-chrome-steel blades.

If relatively long blades are being formed into blade segments, the step of providing lacing wire to the blades to join them at an intermediate point of their lengths by fusion of metals such as the silver soldering described above, may also be resorted to.

If the nickel-chrome blades are not coated with a metal, soldering of the shroud or lacing wire thereto effects an insecure union not having the firmness of the unions contemplated for the blade segments of this invention. In order to provide nickel-chrome blades with a metal coating, they have been dipped in a hot bath of molten silver solder, a step referred to later in this specification. This dipping, aside from the fact that an oxide was formed on the nickel-chrome blades, has the further disadvantage that many blades became cracked because of the high temperature of the bath in which the blades were dipped for coating purposes, and thus had their strength impaired, an impairment of strength just as undesirable as that due to grain growth therein.

The blades now firmly connected and assembled by the end shroud and the intermediate lacing wires, are next subjected to the step of casting on a foundation segment. This step may be carried out by an apparatus such as disclosed in the United States Patent No. 1,620,974 to Klenk, dated March 15th, 1927. Although the specific apparatus for carrying out this step is not material as far as the present invention is concerned, the specific character of the metal of which the foundation segment is made is important. When using steel for casting-in nickel-chrome-steel blades it was found to be difficult to machine the steel foundation because of the very tough and hard crust apparently formed thereon. A composition of metal consisting of nickel and copper has been found to be very satisfactory as a foundation segment and it has practically the same co-efficient of expansion as steel. While the nickel-copper foundation was found to be more suitable than a foundation of steel as far as machining properties were concerned, it had the objectionable characteristic of having blow holes formed therein. When the nickel-chrome blades are, however, electroplated as stated above with silver and thus have a silver coating on the root portion of each blade, the formation of blow holes in the foundation segment is practically eliminated.

In dipping as suggested in the United States Patent No. 1,641,745, it was found that if nickel-chrome blades, preliminarily heated to a temperature of approximately 1200° F., were dipped in a hot bath of molten silver solder at the required temperature of approximately 1500° F., the surfaces of the blades so treated became coated with an oxide. Since the temperature of the molten nickel-copper alloy which forms on cooling the preferred foundation segment of this invention, is as high as the above-described dipping temperature, it may be that an oxide similarly tends to form on the root portion of the blades in casting a nickel-copper foundation segment to the blades, resulting in the formation of blow holes and pores in the foundation segments. But electroplating the blades with silver at room temperature apparently precludes the formation of an oxide on the blade roots during the casting-in process and consequently the objectionable blow holes in the foundation segments are found to be almost entirely eliminated.

The metal must be poured at the proper temperature and the mould must be dry and free from moisture. This is another advantage of silver plating the nickel-chrome-steel blades.

The improved blade-spacing and angling jig, already referred to, will now be described in detail.

Referring to Figures 1 and 2, it will be seen that the jig consists of two frame portions, 1 and 11, cast of a suitable metal. The co-operating jig frame, 11, is slidingly associated with the main jig frame, 1, by being provided with a rectangular slot which receives the rectangular bar, 5, secured to the mid portion of the base of frame, 1, by screws, 6, 6. The frame, 1, is provided with arc-shaped recesses to receive arc-shaped and notched strips, 3 and 4. The strips are so constructed and arranged in the frame, 1, that when the proper edges of the blades are positioned in the notches in the strips, the opposite edges of the blades will be parallel to the base of the frame, 1, and will be disposed about as high as the top of the arc-shaped stop portions, 2 and 12, of the frames, 1 and 11, respectively. The arcs of these stop portions are concentric with the recesses in which strips, 3 and 4, are received. The arc-shaped stop

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portion, 2, of the main jig frame is provided with a plurality of threaded holes for receiving studs, 22, on which a clamping plate, 21, is slipped for the purpose of adjustably pressing the root ends of the blades when positioned in the jig against the strip, 3, by turning the wing nuts, 23, on the studs, 22. In order to avoid damaging the blades it is preferable to place a strip of asbestos, 20, between the clamping plate, 21, and the adjacent edges of the blades.

The co-operating jig frame, 11, is slidably removable from the main frame, 1, by reason of the bar, 5, already described. In order to hold the frame, 11, in a desired position with respect to the frame, 1, or on the bar, 5, the frame, 1, is provided with transversely directed pins, 7, which form the axes of links, 8, having at their other ends threaded tenons, 9, which receive wing nuts, 10. These nuts engage the outer or straight portion of the frame, 11. The inner edge of the frame, 11, is arc-shaped and a plurality of holes, 13, are provided to decrease the arc surface of this edge for purposes of heat dissipation during the soldering operation. A metal strip, 14, is secured against this edge of the frame, 11, by means of screws, 15. The frame, 11, has an inner outline as shown by the dotted lines in Figure 1 for the purpose of reducing the cost and weight of the jig.

The operation of the device is as follows:—The clamping plate, 21, is first removed and the frame member, 11, sufficiently withdrawn to enable the previously silver-plated blades, 17, to be positioned in the notches, 27, in the strips, 3 and 4. The clamping plate, 21, is then applied to the frame, 1, so as to press slightly against the blades. The frame, 11, carrying a shroud-ring segment, 16, is then slid closer to the frame, 1, by operating the wing nuts, 10, until the root ends of the blades uniformly bear against the stop portion, 2, and the other end of the blades uniformly bears against the proper portions of the shroud, 16, as correctly determined by the notched strip, 4. The notched strip, 14, used for spacing and angling the blades at the shroud end thereof is similar to the strip, 3, at the root end of the blades.

The advantage in using the strip, 14, resides in the fact that a plain shroud may be used instead of one that has been provided with pressed-out portions that conform to the shape and desired angling and spacing of the blades in which the shroud end of the blades were formerly held. For the shroud, when provided with the necessary depressed portions, is strained and the presence of the strain is later found to be detrimental and injurious to the shroud when heat is supplied thereto to unite the blades and shroud by fusion of metals as for instance by silver soldering.

Lacing wires are then laid in notches in the edges of the blades or pushed through openings in the blades as shown. The blades are then brazed or soldered as by silver soldering to the shroud and lacing wire. The uniform fillets now obtained in brazing or soldering the lacing wire to nickel-chrome-steel blades after they have been silver plated according to this invention are illustrated by the stippled areas surrounding the lacing wire in Figures 2, 3 and 4. After the shroud has been soldered to the blades the blade segment is removed from the jig by first removing the clamping plate, 21, and then withdrawing frame, 11, from its engagement with the shroud, 16.

A foundation segment is then cast on the root end of the blades by using any suitable apparatus, as for instance that disclosed in the United States Patent to Klenk No. 1,620,974, already referred to.

A composition metal consisting of nickel and copper is preferable to steel as the foundation metal because it is more easily machined.

The specific machining of the foundation may take the form shown by 25 in Figure 4 to co-operate with similar machining in the final supporting element, 26. After these machined portions of the foundation segment and supporting element have been brought into engagement, caulking strips, 24, may be used to hold the assembled blade segments in proper position.

It should be understood that it is not desired to limit the scope of the invention to the exact steps of the process and to the exact details of construction and operation of the apparatus herein shown and described, for various modifications within the scope of the claims may occur to persons skilled in the art.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A process of uniting a co-operating element to a nickel-chrome-steel turbine blade, which includes the step of electroplating said blade with silver prior to the actual operation of uniting the blade and co-operating element, substantially as and for the purpose described.

2. The method of uniting a nickel-chrome-steel turbine blade to an alloy, e.g. of silver solder comprising electro-

plating said blade with silver, fusing said alloy, and casting said fused alloy on to said plated blade at a temperature above the melting point of the silver plating but below that at which grain growth might occur in the nickel-chrome-steel blade.

3. The method of joining a co-operating element to a nickel-chrome-steel turbine blade, comprising electroplating said blade with silver, applying said co-operating element to said blade, heating said blade at the point of juncture with said co-operating element to a temperature not materially greater than that at which said silver plating begins to fuse, and then applying silver solder to said heated point of juncture to unite said co-operating element to said nickel-chrome-steel blade.

4. The method of making a steam turbine blade segment, comprising shaping a plurality of turbine blades from nickel-chrome-steel, electroplating said blades with silver, arranging said plated blades in position to constitute a segment of turbine blading, disposing a shroud ring segment in contact with the ends of said blades, heating the contacting end of each blade and the adjoining shroud ring portion to a temperature not materially greater than that at which the silver plating on the blade end fuses, and applying silver solder to said heated blade end and said shroud-ring portion to join them.

5. Improved methods of uniting turbine blades to co-operating elements and the assemblies so produced, substantially as hereinbefore described with reference to the accompanying drawings.

6. Apparatus for carrying out the methods claimed in the preceding claims, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 1st day of May, 1935.

MARKS & CLERK.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.

[This Drawing is a reproduction of the Original on a reduced scale.]

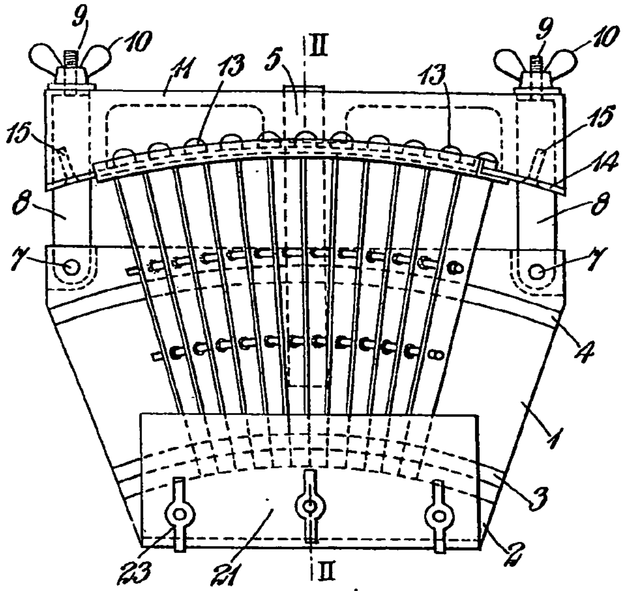

Fig.1.

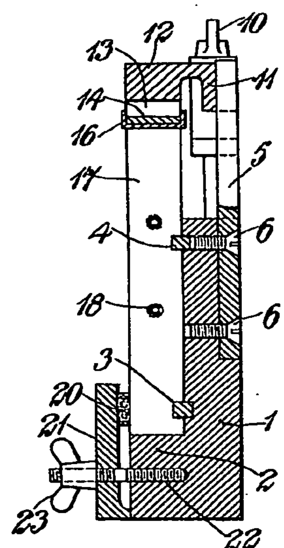

Fig.2.

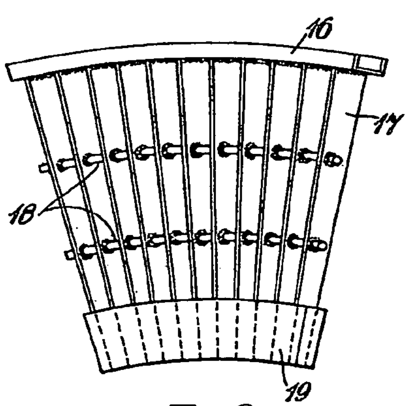

Fig.3.

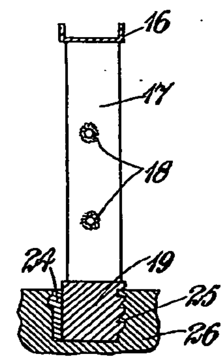

Fig.4.

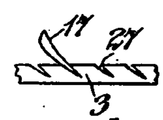

Fig.5.